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ABSTRACT

Iron and steel and pulp and paper industries, two representatives of American industry, are selected in this teacher's guide for the study of industrial pollution and current pollution control efforts. The resource unit is intended to provide the teacher with basic information that will aid classroom review of these problems. Both industries are discussed separately, focusing on the stages of production, air pollution, water pollution, current pollution abatement systems, cost analysis, and attitudes of the industry. A bibliography is included. This work was prepared under an ESEA Title III contract for the project "Broad Spectrum Environmental Education Program." (BL)

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TEACHERS ENVIRONMENTAL RESOURCE UNIT: INDUSTRY: IRON/STEEL & PULP/PAPER

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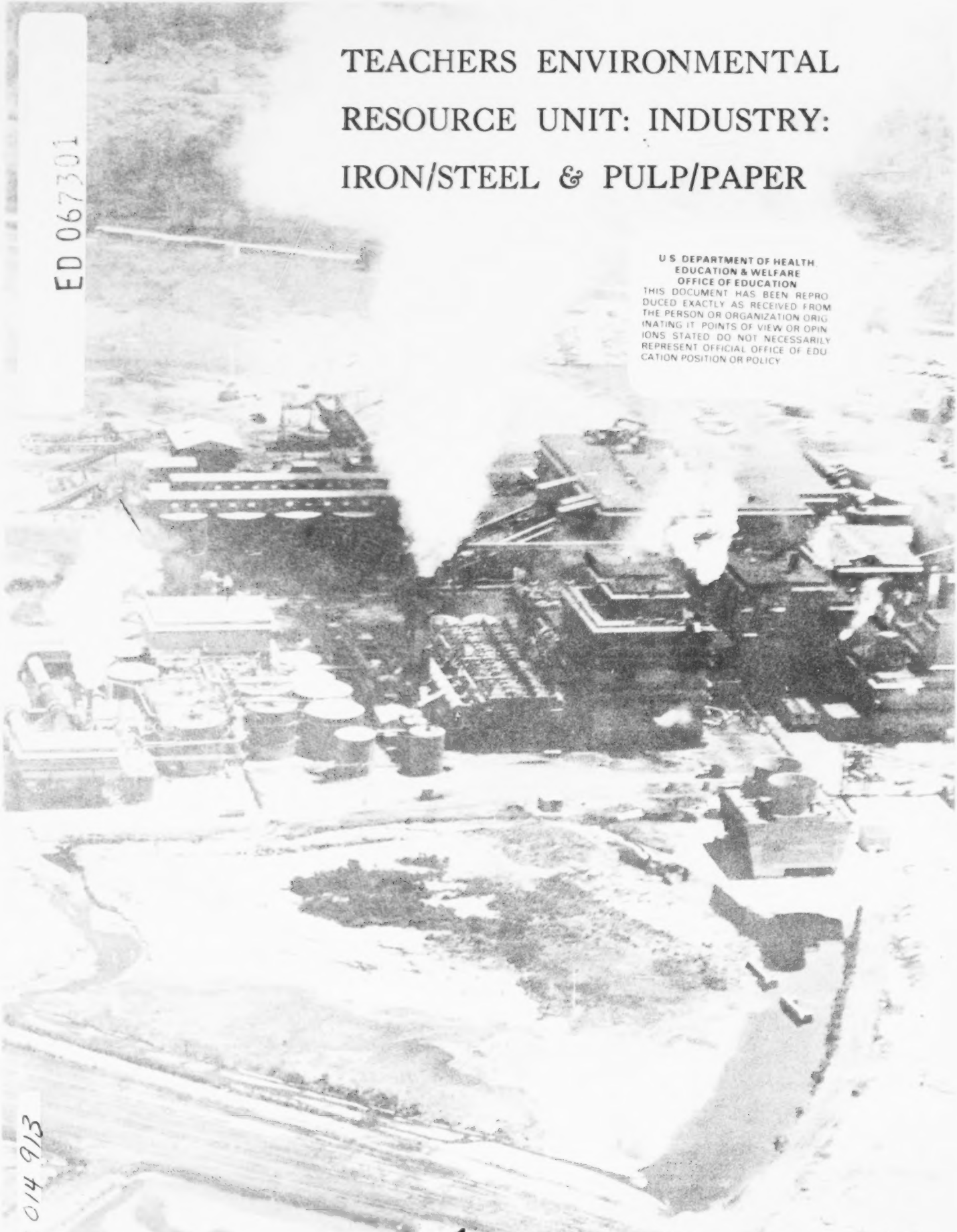

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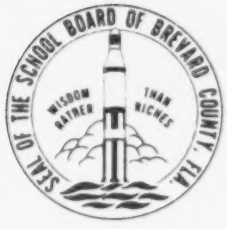

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TEACHERS ENVIRONMENTAL RESOURCE UNIT:

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INTRODUCTION

The factories that are the backbone of American industry are belching and spitting forth enormous quantities of environmental pollutants. Contamination of the environment has reached the point where it affects the lives, health and psyche of the American people. All wish to end the pollution problems that now beset the nation, but who is willing to pay the price?

United States industries have led the world in new technology and discovery for more than forty years and have provided a standard of living that has never before been known to man. At the same time, American foreign aid, in the form of money and technological know-how, has helped to develop the economies of foreign nations to a point where they are now competitive with the industrial production of the United States.

In 1971, U.S. imports exceeded exports for the first time in more than forty years. The impact of foreign goods at a rate that exceeds the export of domestic goods now threatens the basic structure of factories and jobs that support the American economy. As American industry struggles to maintain a favorable market it must also come face to face with the problem of abating widespread pollution, a task that will cost billions of dollars more than was thought only a few short years ago.

The installation of pollution control equipment will account in some cases for as much as 20% of the cost of constructing new plants. Recent estimates of the cost of reducing pollution to acceptable levels for all industry by 1975 are now in the order of $50 billion. Many industries can

pass this added expense along to the consumer by charging higher prices for their products, a technique that should stimulate closer examination by consumers of spending practices directly related to living standards. Some industries are also beginning to derive new and marketable products from what was once waste material dumped in assorted grotesque forms upon the American landscape. Yet, for many industries, it will not be possible to maintain profit margins by raising prices, nor practical to derive new products from waste. Unfortunately, most of these industries are the smaller, less diversified plants that still make up a large part of our productive Gross National Product.

The methods that industry chooses to employ now in an effort to curb pollution will have profound effects upon generations to come. Our youth must therefore begin to take part in a careful examination of the process of economic and social change that increased awareness of critical environmental needs has brought about. This resource unit is intended to provide basic information in support of this examination. As it is written new ideas are being generated and new data is being published. What economic decisions transpire even on a daily basis will add new insight to the information contained in the unit. But we must choose a point to begin.

For the purpose of this unit, the iron and steel and the pulp and paper industries have been selected as two representatives of American industry. How they choose or are required to react to the current environmental and economic crisis will have much to say about the future of the American economy and consequently the quality of life of all who are involved.

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I. THE IRON AND STEEL INDUSTRY: POLLUTION AND POLLUTION CONTROL

A. STAGES OF PRODUCTION

It should be pointed out at the beginning that any serious study of pollution problems in the iron and steel industry must be accompanied with knowledge of the process of steel making. Massive quantities of raw materials are required in the steel production process. Dramatic chemical transformations take place which call for massive facilities, that require years and large sums of money to construct. Changing or replacing facilities of this nature is a slow and costly process. This fact should be kept in mind as we study the pollution control problem of the iron and steel industry, for it may represent the greatest pollution abatement investment in the American economy. Estimates of the cost of pollution control equipment for the industry run between 10 and 20 per cent of the total capital invested, or in the order of many millions of dollars.

The first step in the steel production process is to bring the raw materials of iron ore, limestone and coal, together with huge quantities of oxygen and water.

1. Iron Ore

Iron ore, if in pure enough form after mining, goes straight to the blast furnace for processing. If it needs refinement, it is sent to a sinter or pellet furnace where the impurities are extracted to produce a higher grade ore in the form of "cake" or "pellets". This refined ore is then ready

for the blast furnace.

2. Limestone

Limestone is the remains of what was once marine animal and shellfish life. It is found in large quantities in almost every state in the nation. This vast resource yields about 30 million tons annually for production purposes. Limestone that is used in steel processing is consumed as a fluxing material in the blast furnace that combines with the impurities of iron ore to form a waste known as slag.

3. Coal

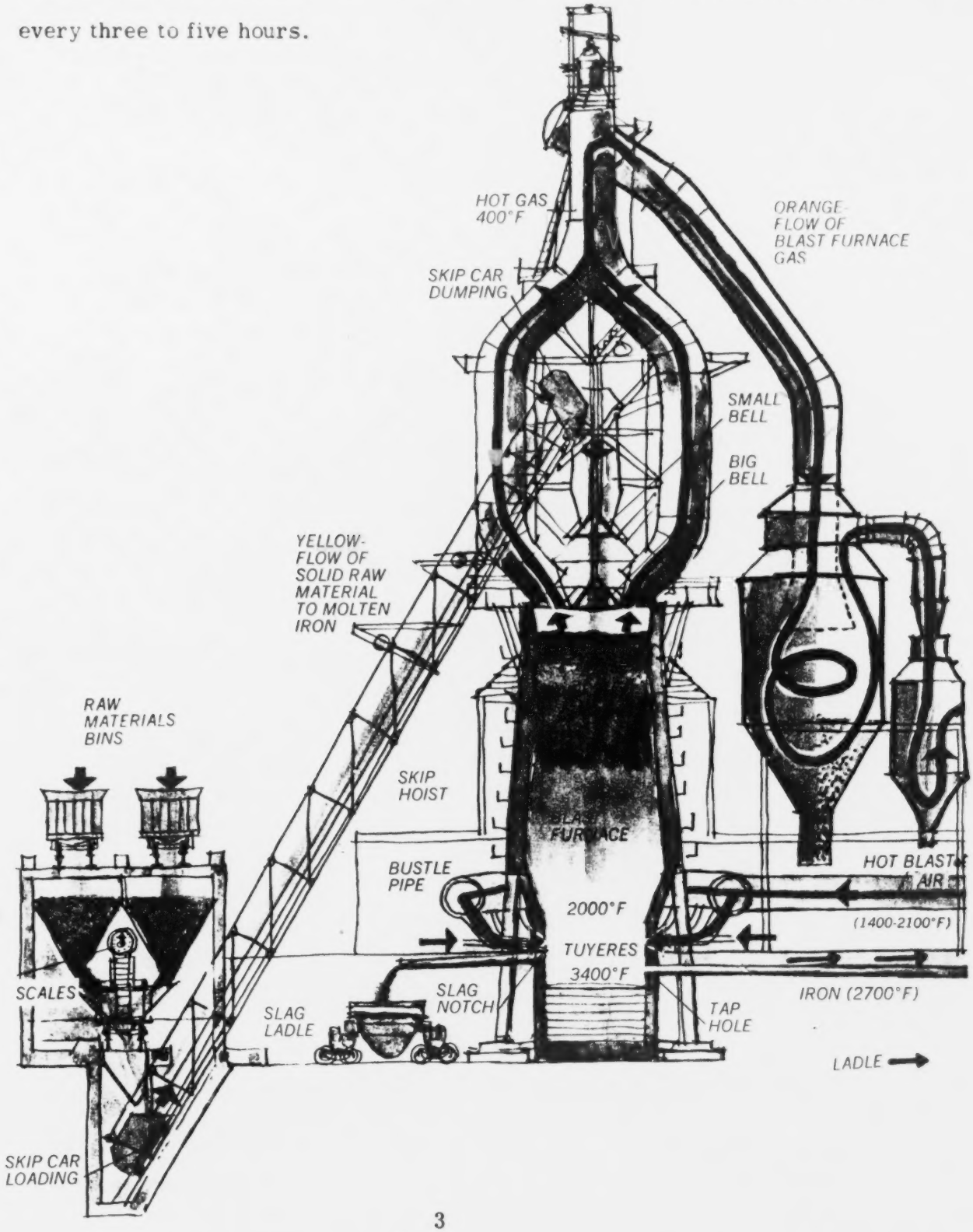
Solid bituminous coal is baked for 12 to 18 hours at temperatures as high as 2,000 degrees Fahrenheit. The heat drives off gases and tar and leaves a porous powder fuel known as coke. Coke is an essential ingredient because unlike the coal it is derived from, it burns inside as well as outside and does not fuse with the iron ore or limestone as the three raw materials meet at the blast furnace for the production of pig iron.

4. Blast Furnace

The blast furnace is a huge steel shell lined with heat resistant brick. The raw materials of ore, coke and limestone are fed into the top of the furnace in the desired amounts. At the same time air, which is also an indispensable raw material, pours in at the bottom of the furnace and roars up through the charge of iron ore, coke and limestone.

When fanned by the air, the coke burns. Its gases reduce the ore to metallic iron by removing oxygen, while the limestone causes the ore to flow. The heavy metal then settles to the bottom of the furnace. The yield,

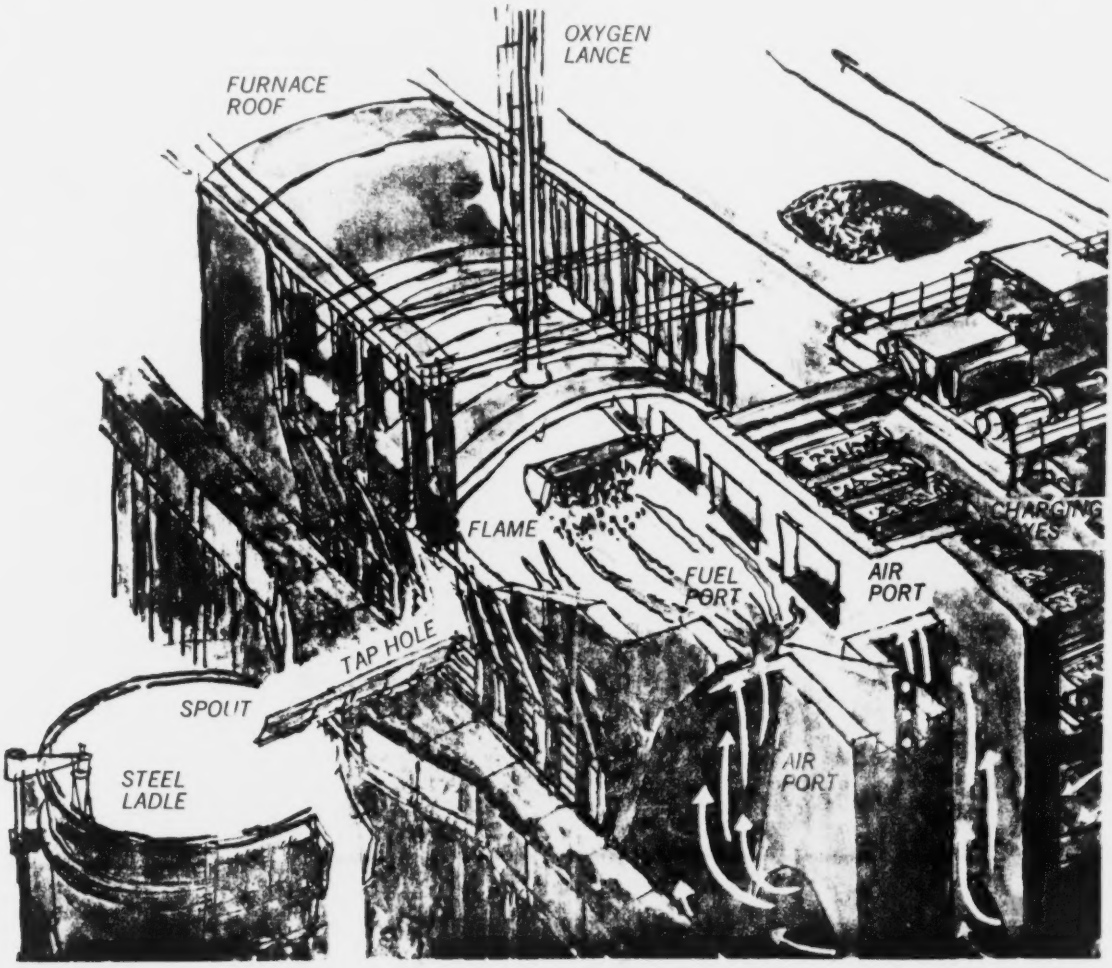
at present production rates, is from 300 to 600 tons of crude or pig iron every three to five hours.



5. Open Hearth Furnace

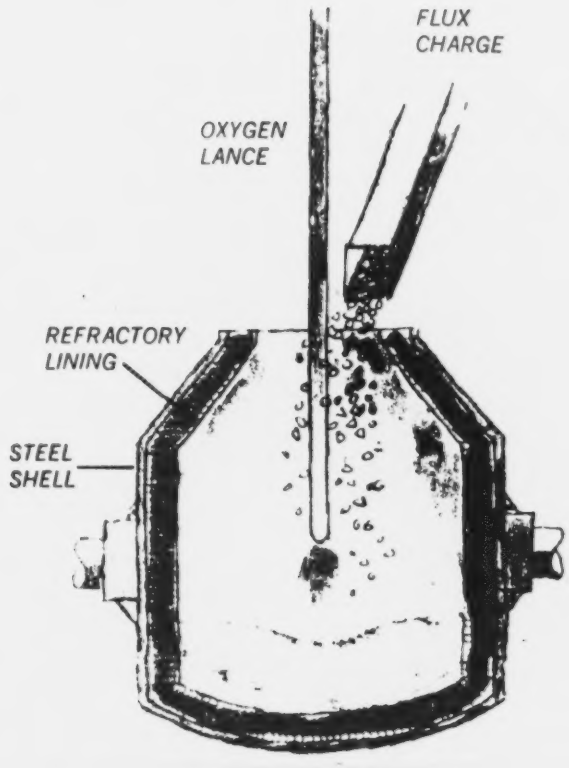
The crude, molten iron produced by the blast furnace is then transferred to either the open hearth furnace, basic oxygen furnace or the electric furnace for further refining and tempering.

The oldest and most elementary furnace for the processing of molten iron is the Open Hearth Furnace. It is so named because the limestone, scrap steel, and molten iron charged into the shallow hearth is open and exposed to the sweep of flames. The typical open hearth furnace produces an average of 350 tons of steel in five to eight hours.



6. Basic Oxygen Furnace

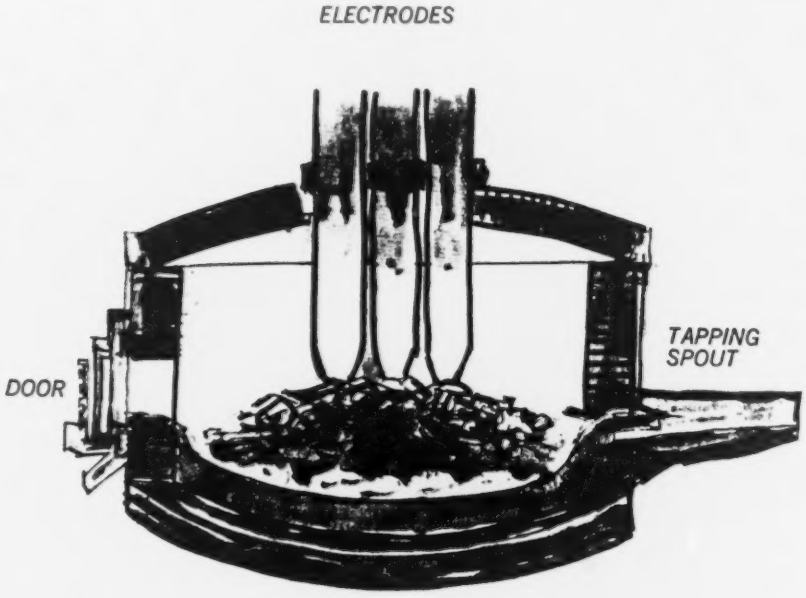
The most popular furnace being used today is the Basic Oxygen Furnace. This furnace uses no other gases or fuels other than pure oxygen and is capable of producing 300 tons of steel in 45 minutes. The method requires a water cooled oxygen lance which is lowered into the furnace while extremely pure oxygen is blown onto the top of the metal at supersonic speed. Oxygen combines with carbon and other unwanted elements, eliminating these impurities from the molten charge and converting it to steel.



During the oxygen blow, lime is added as a flux to help carry off the oxidized impurities as a floating layer of slag. Lime is consumed at a rate of about 150 pounds per ton of raw steel produced.

7. Electric Furnace

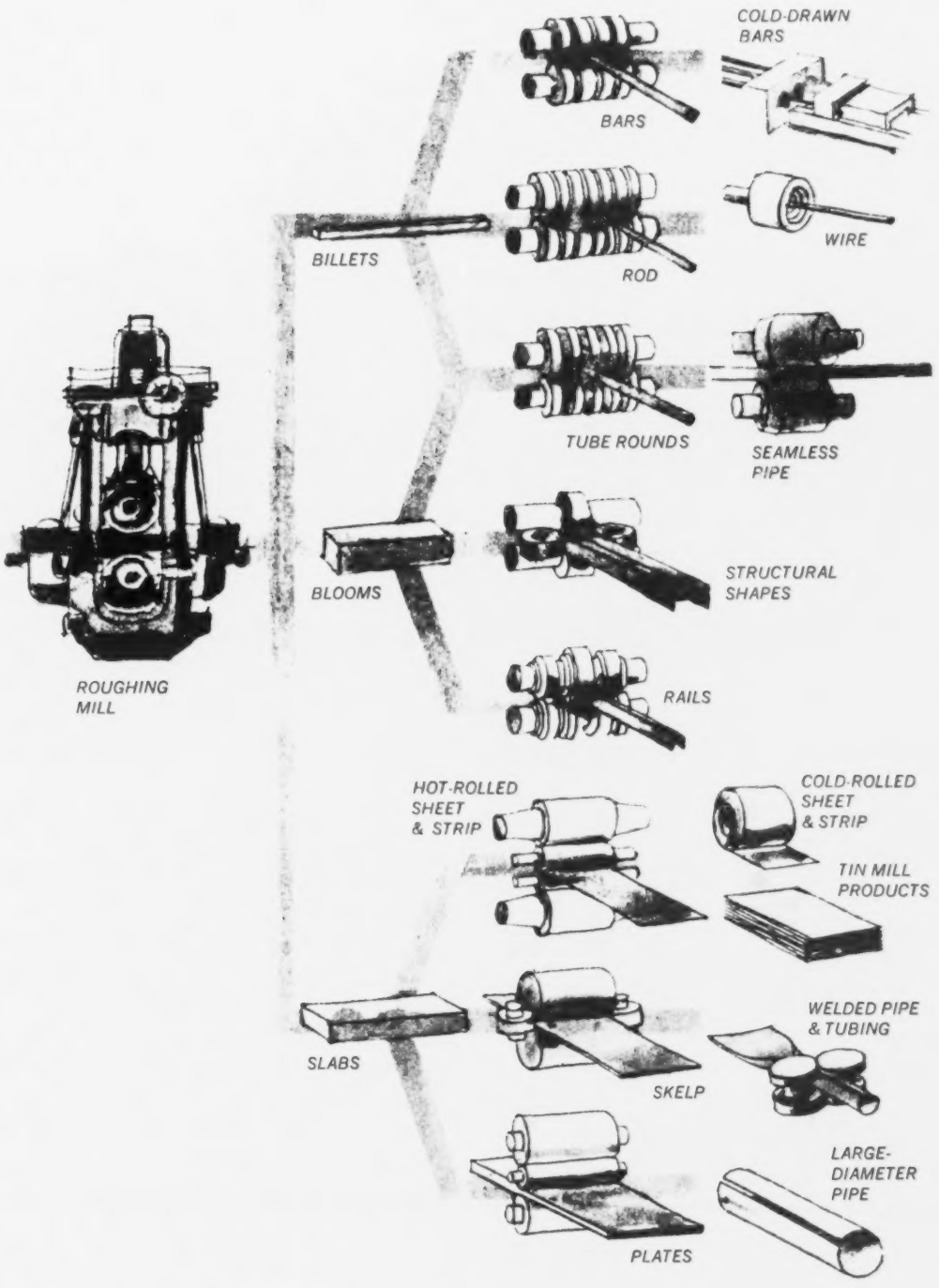
The Electric Furnace produces alloy, stainless, tool and other specialty steel. In this process electrodes are lowered through the roof of the furnace and the electric power is turned on. The current within the furnace arcs from one electrode to the metallic charge and from the charge to the next electrode. The electric furnace is a relatively new and improved method of producing ferroalloys.



8. Roughing Mill

As the molten steel comes from the furnaces it is poured into molds of various sizes called ingots. As the steel cools and solidifies it is carried

to the roughing mill where it will be rolled into the desired size of slabs, bullets or blooms. It is then passed on to other mills for further rolling.



B. AIR POLLUTION

Air pollution has existed to some degree ever since the simmering of the first volcano. Man began to add his share to atmospheric pollution when he began to use fire, but with the arrival of the Industrial Revolution, man's capacity to pollute with the tools of industrial technology took on new and frightening dimensions. But it is only recently that large numbers of people in this country and throughout the world have begun to realize the incredible extent to which man is capable of degrading the air he breaths. The same industrial and technological expansion that has created what is believed to be the highest standard of living in the world has also left much of the American landscape unfit for healthy habitation. We have already begun to hear of the relocation of people because high levels of industrial air pollution have gone unchecked and endangered their lives.[1]

The broad classification that includes all industry is second only to the automobile in the production of air pollutants. These pollutants include carbon monoxide, sulfur dioxide, hydrogen sulfide, amonia vapor, and particulate matter. Industrial particulate matter is more commonly known as fly ash or soot. While fly ash is emitted from the smoke stacks of most industrial plants, no industry has been more commonly associated with its production than the iron and steel industry.

The iron and steel industry is still at the heart of the industrial age and is intricately involved and influenced by information and techniques that are being developed to clean up the environment. The industry includes plants ranging from large iron foundry and integrated steel making operations,

to smaller operations that produce specialty steels. Our attention for the purpose of examining air pollution will be focused primarily on steel making operations.

The initial step in steel production is the coking process. Bituminous coal is converted into coke and used as the chief fuel in the sinter, blast or open hearth furnace. Pig iron produced in the blast furnace goes to the open hearth, basic oxygen, or electric furnace for the processing of steel. From here it is milled and rolled into the finished product. It is from these processes that the principal air pollutants are created.

1. Carbon Monoxide

Carbon monoxide is emitted from the basic oxygen furnace and blast furnace. It is a poisonous gas, and has consequently been generally controlled to low emission levels in recent years.

2. Sulfur Dioxide

Sulfur dioxide emissions are a result of the burning of soft coal in the process of making coke. Although it is odorless, it irritates the eyes and lungs, and in sufficient quantities is highly toxic. It also reacts easily with the sun and nitrogen oxides to form photochemical smog. An example of the steel industries capacity to release sulfur dioxide is U. S. Steel's Clairton, Pennsylvania plant which emits some sixty tons of sulfur dioxide daily.[2]

3. Hydrogen Sulfide

Hydrogen sulfide smells like rotten eggs and has been the trademark of steel towns. This gas is formed when water is used to cool hot slage. It

is highly toxic to humans in large quantities and has also been known to damage vegetation.

4. Ammonia Vapor

Ammonia vapor is a gas composed of nitrogen and hydrogen which is given off from the coking ovens and from the various cooling processes. Although colorless, it is quite pungent, and in high concentrations can be harmful, if not fatal, to humans.

5. Fly Ash

Certainly the most visible of all air pollutants is fly ash. It is the waste minerals of coal and is contained in the black particle-laiden smoke that bellows from steel mill stacks. Fly ash is not extremely harmful to humans, unless inhaled in large quantities, but it does cause considerable environmental damage as it covers everything within miles of the milling area. Its main offense is its unsightly, ever-accumulating presence.

C. WATER POLLUTION

Water is an essential element in the process of making steel. It is used in the production of coke, cooling the furnaces, steam for turbines, washing furnace gases and for the removing of scale from rolling mill products. It is estimated that this country's steel industry uses some eight billion gallons of water per day for cooling and production purposes.[3] The Bethlehem Company alone requires some 550 billion gallons a year or 27,300 gallons for each ton of steel produced. Approximately 90 per cent of this water returns to its source and only 10 per cent is lost through evaporation.[4] The 90 per cent that is returned to the environment is the point of concern. As the water is used it becomes a liquid waste consisting of oil, ammonia, cyanide, and phenols, that contaminates our rivers, lakes and streams and all too often prevents them from supporting life. Extreme, but representative examples of such devastation are the Cuyahoga River in Cleveland and the Monongahela River in Pittsburgh, which cannot support aquatic life and have literally become fire hazards that must be constantly observed by their respective Fire Departments.

1. Ammonia

During production, water used primarily in the cooling of the ovens, furnaces, and slag, becomes heavily contaminated with hydrogen and nitrogen that combine to form toxic ammonia.

2. Cyanide Acids

These are colorless, poisonous, unstable acids which are formed from various combinations of the elements of hydrogen, oxygen, carbon,

and nitrogen. Cyanide acids are useful in the case hardening of the steel, but unfortunately, they become part of the waste water that is returned to the environment.

3. Phenols

An aromatic compound of carbon, hydrogen, and oxygen (C_6H_5OH), it is produced from the coal tar burned in the coke ovens, and is added to the flow of water through the plant.

4. Oil

Oil residues of many kinds return as part of the water which has been accumulated from the production process. Most of the oil residue is provided by the various milling processes.

D. CURRENT POLLUTION ABATEMENT

In 1970 the Environmental Protection Agency was given the authority and power to set standards for ambient air and water quality. Recently, the EPA exercised its authority by taking legal action in shutting down 23 mills and foundries in the Birmingham, Alabama area. The EPA hopes that by taking this type of action the steel companies can be convinced that it will not be any cheaper for them to postpone the development of technology and equipment necessary to eliminate air and water pollution.

The steel industry is beginning to take steps in the direction of pollution control. For example, Republic Steel is completing an $18 million waste water treatment plant. U. S. Steel has a cumulative investment of well over $235 million. All total, the American Iron and Steel Institute figures that reporting members are currently budgeting over $325 million per year for pollution control of one kind or another.[5] Of the new mills being built, pollution control equipment accounts for 10 to 20 per cent of the construction costs.

Sacrifice, however, is not without reward. As the industry attempts to control and eliminate its destruction of the environment, it discovers better and more profitable means of production. Notable of this innovative technology, is the replacement of the open-hearth process furnace with the basic oxygen furnace.

The major problem in the steel industry's attempt to end pollution, is that old plants cannot be torn down and replaced overnight. Then too, consideration must be given the predicament of the small steel mills that

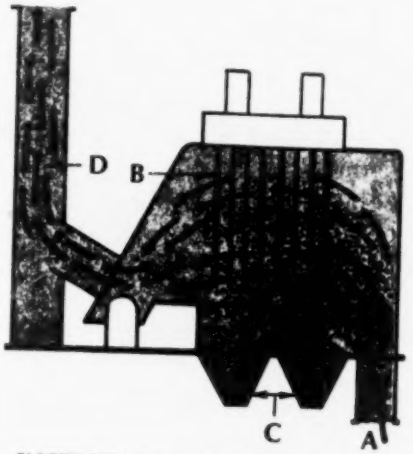
will suffer because they cannot carry the cost of conversion to new anti-pollution production techniques. These plants, however small they may be, taken together represent a substantial portion of this country's steel production capacity. Cost estimates published by the steel industry indicate that as Federal Clean Air Act standards are enforced, three-fourths of the small mills will cease to exist.[6]

1. Air Pollution Control

The major types of pollution abatement devices currently being used are electrostatic precipitators, wet scrubbers, solid and chemical filtration equipment and baghouse.

a. Electrostatic Precipitator

The electrostatic precipitator used on both the open hearth and basic oxygen furnace utilizes electrodes to induce an electric charge on the fly ash particles as they are directed through passages in the plant. The Walls of the passages have a charge opposite to that of the dust particles, in order to attract them to the wall. An automatic-rapping system knocks the accumulated dust into storage hoppers for disposal.



ELECTROSTATIC PRECIPITATOR

A—Dust-laden particles from the furnace
B—Collecting plates
C—Dust storage hoppers
D—Cleansed gases are discharged through a stack

The electrostatic precipitators are 99 per cent efficient in cleaning fly ash from the air. They are designed for plants that are not located by large bodies of water, in which case wet scrubbers are more economically feasible. The Bethlehem plant in Pennsylvania recently installed electrostatic precipitators at a cost amounting to $5 million.[7]

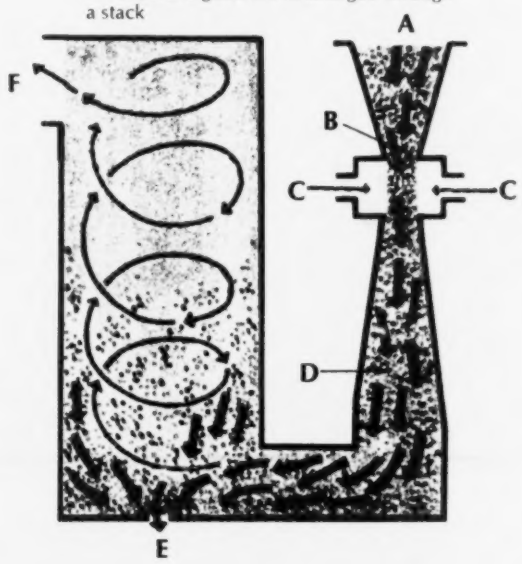
b. Wet Scrubber

Also designed to virtually eliminate particulate matter generated by the open hearth and basic oxygen furnace is the high energy wet scrubber. Capable of recovering better than 99 per cent of the fine fume particles released by the furnaces, the wet scrubbers must be located near large bodies of water because a typical system may require as much as 12,000 gallons of water per minute.

The polluted air from the furnaces is blown into the scrubber and through the spray of water. The dust particles become heavy with moisture and are caught in the wash water that is then sent to treatment facilities.

HIGH-ENERGY WET SCRUBBER

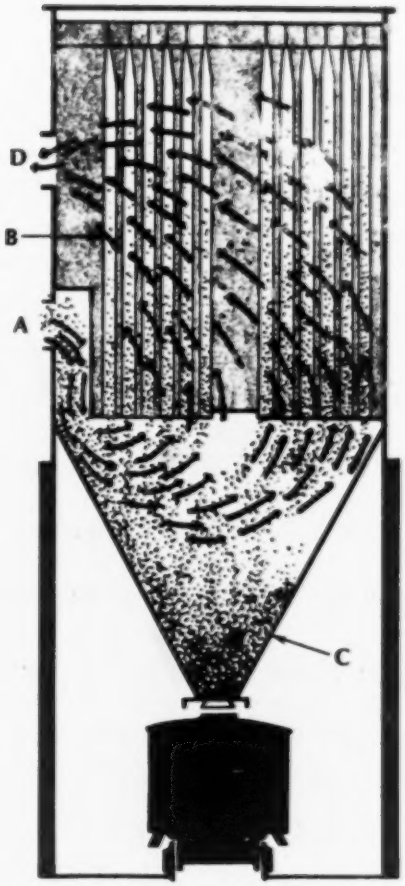
A—Dust-laden gases from the furnace
B—Venturi throat
C—Scrubber
D—Wetted particles
E—Wash water to treatment facilities
F—Cleansed gases are discharged through a stack



c. Baghouse

Recently the Bethlehem plant in Steelton, Pennsylvania replaced their open hearth furnaces with three 150-ton electric furnaces costing $12 million, of which $2 million was invested for a Baghouse System to collect dust and fumes.[8]

The baghouse system operates on the same principle as a household vacuum cleaner. It is designed to remove submicron particles from the air. As the polluted air passes through a series of large bags, they remove the fine particulate matter, permitting only clean air to return to the atmosphere.



BAGHOUSE DUST COLLECTOR

A—Dust-laden particles from the furnace
B—Filter bags
C—Dust storage hoppers
D—Cleansed gases are discharged through a stack

The system also processes fumes produced from hot-scarfing and from pouring of leaded steels.

2. Water Pollution Control

Careful steps must be taken to cleanse the water used in the production process before it is returned to its source. Settling pools, catch basins, and clarifiers are the principal methods being used to remove metal sediments and oils and to render acid wastes harmless. Also, with increasing frequency, closed circuit water systems are being developed which recycle the same water through the plant again and again. Typical of the expenditure necessary to clean waste water is Bethlehem's Burns Harbor Indiana plant which has authorized expenditures for more than $37 million in water pollution control.[9]

a. Closed Circuit Water System

Typical of a closed system is the type that may be used at the blast furnace which handles water from the gas washer and cooler. The water is chemically treated, clarified, cooled, and then recirculated.

b. Scaling Pits

The first stage of treatment for the contaminated waste water may be the scaling pits or lagoons. Here the suspended solids in the water are given a chance to settle to the bottom while the oil residues rise to the top. The oil and particulates are removed, making the water ready for further treatment.

c. Thickener Lagoons

Waste water from the scaling pits then flows to the thickener lagoon where chemicals are added which cause the remaining foreign properties to collect (or thicken) together and settle to the bottom.

d. Holding Lagoon

If the water from the thickening lagoon is thought to be of high enough quality, it is moved to a holding lagoon for further settling and from here returned to its source.

e. High-Rate Sand Filter

When the waste water of the thickening lagoon remains too contaminated to return to its source it is sent to a high-rate sand filter that further reduces its content of foreign matter.

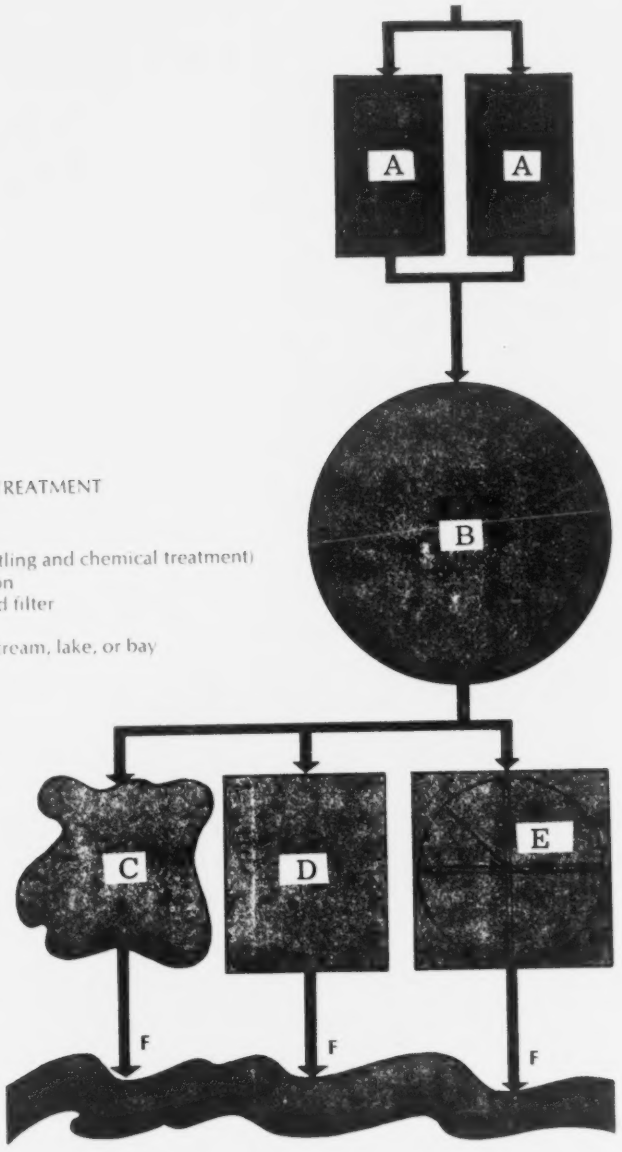
f. Clarifier

Water that is still highly contaminated goes to a clarifier for further treatment by a "flocculator" that turns solid wastes into small lumps that settle to the bottom in the clarifier tanks.

g. Acid Wastes

A number of companies dispose of acid wastes, which result from steel cleaning processes, by sinking deep wells through layers of rock and then discharging acids into the permeable strata below. Unfortunately, the "long term" effects of this type of disposal are not yet known, but certain "local area" examples have indicated deleterious effects on water supply "aquifers" existing at various depths. These subterranean tables have an inherent means of rejuvenating slightly contaiminted ground water, but cannot survive the injection of large quantities of acids, bases or organic chemicals.

A TYPICAL WASTE WATER TREATMENT PLANT



WASTE WATER TREATMENT

A—Scale pits
B—Thickener (settling and chemical treatment)
C—Holding lagoon
D—High-rate sand filter
E—Clarifier
F—To receiving stream, lake, or bay

E. COST ANALYSIS

In 1967 there were 142 steel plants in the United States. One hundred thirty-four of these were located in 298 metropolitan areas. The production capacity for these metropolitan plants was 127 million tons valued at $13.3 billion.[10]

The total number of steel plants in the United States in 1967 represented 86 steel compnaies. Twenty-one of these companies accounted for more than 90 per cent of 1967 steel production. The U. S. and Bethlehem Steel companies alone accounted for 40 per cent of the total.

The major markets for steel production are the motor vehicle, heavy equipment, machinery and container industries. The extent to which these industries are affected by the nation's business cycle has a direct effect on the market for finished steel.[11]

As a result of the iron and steel industry's susceptability to economic changes, coupled with ever-increasing foreign competition and high labor costs, the profit margin for the iron and steel industry tends to be low. The average profit before taxes is between six and seven per cent for the larger firms and five and six per cent for the small companies.

The industry generally is not an attractive investment in stock or bond markets, due to its low rate of return and slow profit growth. The added costs of pollution control equipment represents a reduction in profit margins for some and a reason for going out of business for others. The average cost of equipment control, per ton based on 1967 indexes is $5.88 to $6.01 depending on existing equipment and the location of plants.[12] For

example, different furnaces have different control costs and even the same furnaces with differing capacities will not incur the same control costs. Plant location will have something to say about the type of control equipment used,as in the case of wet scrubbers that are more economically feasible for plants located near water. At any rate, cost estimates based on 1967 figures indicate an increase in operating costs between 0.7 per cent and 3.0 per cent, again, depending on the size of the plant and the type of equipment used. Consequently, the iron and steel industry is facing, before taxes, reductions of 0.7 to 3.0 per cent of their five to seven per cent profit margins. This will encourage portions of the industry to postpone implementation of control equipment for as long as possible. At the same time, it must be pointed out that the iron and steel industry has spent more money than any other industry on pollution control equipment relative to its total capital investment.

In the long run, the larger firms will actually gain from pollution control, as it will not only provide new technology, but may eliminate many small scale competitors, providing increased control of an already highly monopolized industry.

F. ATTITUDES OF THE IRON AND STEEL INDUSTRY

At a time when the Iron and Steel Industry is facing severe competition from foreign producers, and high labor cost in an inflating and unstable economy, the establishment of pollution control standards seems economically inappropriate. Yet, in a free enterprize system supported by competition the pollution problems of the steel industry, as well as those of all industry must be accepted as a challenge. The extent to which the challenge is realized and acted upon will determine the future quality of civilized life.

II. THE PULP AND PAPER INDUSTRY: POLLUTION AND POLLUTION CONTROL

There is no fabricated product used more extensively than paper. Paper was employed originally as a medium for writing. As such, it has played a significant role in the development of civilization and culture. Writing papers today, however, account for a relatively small proportion of the output of the paper industry. Paper production in the United States has lead the world for many years. In 1964 annual per capita consumption of paper products was close to 400 lbs. compared to an average per capita need of about 60 lbs. in other highly developed nations.[1] In 1969 the United States required close to 50 million tons of paper products or an average of about 150,000 tons per day. In 1970 the United States consumed 9.5 million tons of newsprint alone (one recent edition of the Los Angeles Times required 3,100 tons of newsprint) compared to 5.8 million tons for all of Western Europe.[2] When one looks at the demand for paper products it is not surprising that the pulp and paper industry is the fifth largest in the United States (a large percentage of our supply of pulp and paper products still comes from Canada where the industry ranks first) and that annual sales in 1970 amounted to a gross value of nearly $20 billion.

A. STAGES OF PRODUCTION

The term paper is traditionally applied to felted or matted sheets of cellulose fibers, formed on a fine wire screen from a dilute water suspension, and bonded together as the water is removed and the sheet is dried. Of the many raw materials used by the paper industry, cellulose fibers have occupied the dominant position for thousands of years. Other fibrous

materials, particularly synthetics, are assuming greater importance in paper making, but it is predicted that cellulose will continue to play the key role for many years.

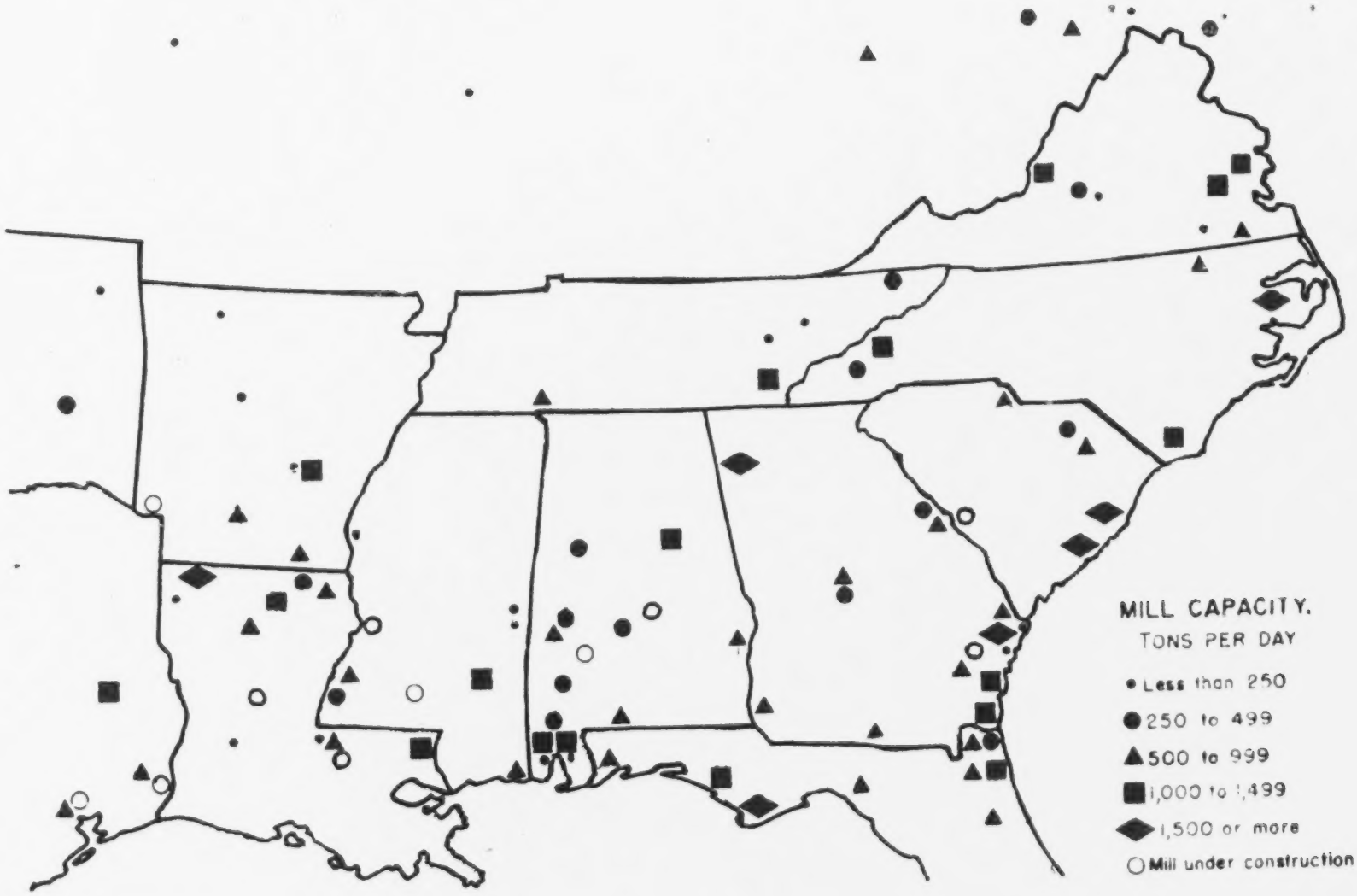
Wood is the primary source of cellulose fibers for paper making. Before use, the wood must be reduced to the fibrous state; this operation is called pulping.

1. Forest Resources

Nearly all the world's pulp mills are located in the temperate zones because the woods most often used for pulping are the conifers or softwood trees, although pulping of deciduous species is also practiced. A sizeable pulp wood industry has existed in the northern United States, but threatened depletion of the forest resources in this region, along with improved pulping processes, has encouraged the establishment of mills in the southern United States.

One cord (128 cu. ft.) of piled wood, or about 90 to 95 cu. ft. of solid wood, will produce an average of one ton of ground wood pulp or half a ton of unbleached chemical pulp. To better visualize utilization of trees by the pulp and paper industry, take one pine seedling. Let it grow for 10 to 17 years. It will produce 400 lbs. of wood which is converted into 120 lbs. of tough kraft paper, which can be further processed into 3,600 12-lb. grocery bags, or 3,000 5-lb. sugar bags, or 500 2-ply 15-lb. potato bags. In 1971 about 41 million tons of wood pulp products such as these were produced in the United States.[3]

Along with the upsurge in housing construction, the paper industry's



1966: MILLS USING SOUTHERN PULPWOOD AND THOSE UNDER CONSTRUCTION

heavy demand for timber has caused a good deal of environmental concern. The most economical and profitable logging procedure is clear-cutting, as opposed to selective-cutting (clear-cutting contributes 60 per cent of the current timber yield).[4] However, clear-cutting exposes denuded land to soil erosion, especially, when followed by fire. Eventually, the silt, humus, and fertility elements are washed away.

In a controlled study, the Hubbard Brook Experimental Forest (central New Hampshire) took over a clear-cut forest, applied herbicide and compared run-off to an intact stand of beech maple, and birch trees. The increase in run-off was found to be as high as 40%. Nitrates and other nutrients rapidly leached out of the soil into streams, which resulted in an abnormal algae growth. But some foresters argue that harvesting old trees under these conditions intensifies growth of young oxygen-producing stands, and improves forage conditions for wildlife. Georgia State University biologist, Charles Wharton asks - "What wildlife are they talking about? Do they mean a game species as deer which comes in for a few years to take advantage of the new opening, or the balanced fauna of a mature forest?"[5] Wharton believes clear-cutting and planting uniform stands of trees destroy the diversity of a forest and may herald the decline of the forest ecosystem.

On privately owned lands the problem appears to many to be critical, but because of the demand, government forests are also being sought. Nearly 3/4 of existing woodlands (368,300,000 acres) belong to private owners. The rest is controlled by federal, state, and local governments. The estimated total land holdings of all pulp and paper companies amounts to fifty million acres, or an area the size of the New England states with

New Jersey thrown in. Paper companies control about 52 per cent of the land in the state of Maine. International Paper, the largest company in the industry, ranks second in land ownership in the U. S. Only the Federal Government controls more land.

The industry's response to criticism of its timber cutting practices is typified by the following statement by Robert O. Lee, vice-president of Georgia-Pacific Corporation (Portland, Oregon): "Most people accuse lumbermen of destroying the forest, but in stands of 50-year growth-cycle timber, for instance, we harvest only 2% a year. The other 98%, ranging from seedlings to full gorwn trees, is green and growing. Our policy is to grow more than we harvest. Timber after all is a crop, not unlike wheat or corn, except that only a fraction of our crop is cut in any one year."[6]

2. Manufacturing Pulp and Paper Products

Cellulose fibers are not the only source of paper. Grasses, seeds, and agricultural residues find considerable use, principally in Europe and the Far East. Cotton rags were used for early paper production in the United States, and are still employed to a minor extent. In the middle of the nineteenth century the scarcity of rags coupled with increased demand for paper generated the eventual development of three principal means of pulp production from cellulose fibers in the United States: mechanical, full chemical, and semichemical.

Mechanical pulping reduces logs into pulp by means of large revolving grindstones. Water is sprayed against the stone to control the temperature and to carry away the resulting pulp. Only a few components

of the wood are dissolved in the water making the process nearly 95% effective.

Semichemical pulping, although relatively new and unused compared to mechanical and full chemical pulping practices is of great current interest. Several processes are used in which mild chemical reactions separate cellulose fibers from other wood components, followed by mechanical attrition. Deciduous wood species are the primary timber source. Pulp yield currently varies from 60 to 95 per cent, depending upon the chemical and mechanical means employed.

Full chemical pulping uses chemical reagents to separate cellulose fibers from the sugars and lignins which hold the wood fibers together. Pulp yields in this case are usually about 50 per cent of the wood weight.

The sulfite process is one full chemical process used largely for pulping spruce, balsam fir, and hemlock, although some hardwoods are also used. The wood is cooked in acids that vary from calcium-base to magnesium, ammonia, or sodium as the base. Sulfite pulps are relatively light in color, are easily bleached, have moderately good strength, and are widely used in fine papers. This process is declining as a significant source of pulp production.

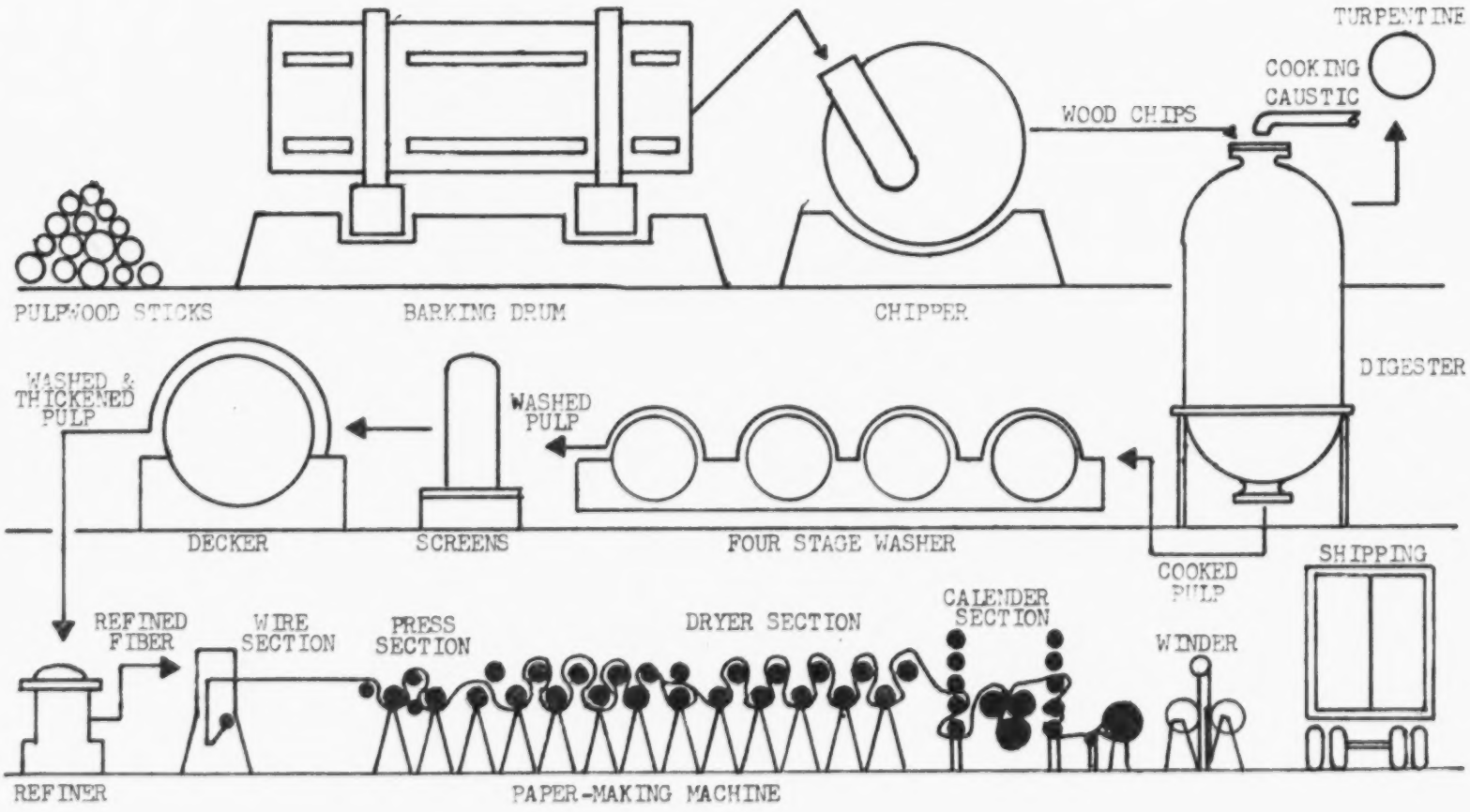
The Kraft or sulfate full chemical process is the most extensively employed today. In 1968 the United States produced 38 million short tons of pulp. Thirty-two million tons were produced by full chemical processes, 75% of which included Kraft pulps. The primary chemical ingredients are sodium hydroxide and sodium sulfide in a strong alkaline solution.

Almost any wood species can be pulped by this process.

The waste that results from this chemical process is called black liquor and may total as much as 50 per cent of the original material. In most mills water is evaporated from the liquor and some of the organic material is burned as a fuel to generate steam. Some is recovered as a binder for roads and foundry cores, while some is neutralized and the sugars used to form potable and commercial alcohols, which in turn are used as raw materials for the production of organic chemicals. Vanillin flavoring is even derived from this liquor.

The cellulose fiber obtained from this process is further refined and bleached before being made into paper. Kraft pulps are dark in color and difficult to bleach, but they are very strong. Chlorine is used in the bleaching process to combine with lignins and form a soluble compound. Oxidation by the chlorine compounds of other substances render the fibers colorless. In the bleached form, kraft pulps are used in fine papers. In the unbleached state, they are employed widely in the container field.

It is the chemical methods of pulp production that cause significant pollution problems. Since the kraft process accounts for nearly 64 per cent of the total industry output,[7] our attention for the purpose of examining environmental pollution caused by the pulp and paper industry will be centered on this process. Sulfite pulping is also a potentially serious source of sulfur dioxide, but it is a declining industry and when waste liquor incineration is practiced, the control costs are more than offset.



This flow chart shows the principal steps involved in converting wood to pulp to paper. It results in the manufacture of Kraft papers. Kraft is a Swedish word meaning "strength" which is a necessity for paper used in making bags, cartons, and wrapping materials.

The same process, using different cooking chemicals, produces book and writing papers, food and liquid packaging materials, rayon for fabrics, building and insulating materials, to mention only a few of the various end products of wood pulp.

B. AIR POLLUTION

Until recently, residents of many mill towns rationalized the nearly unbearable atmosphere around them as something that had to be tolerated in the name of economic prosperity. Lately, however, a counter theme of complaints has been heard. Staggering quantities of air pollutants are discharged from many pulp mills. The 120 U. S. mills which use the kraft pulping process annually emit 630 thousand tons of particulates, over $2\frac{1}{2}$ million tons of carbon monoxide gas, and 84 thousand tons of gaseous sulfur oxides.[8]

The quantity of air pollutants emitted depends upon the particular pulping method employed, and the fuel that is burned to produce steam for generating electrical power or heat for the various stages of the production process. Almost all mills burn some sort of fuel (coal, oil, natural gas) or waste (bark, usable wood scraps, black liquor residue) and thereby emit some particulates in the form of carbon ash, soot, and dust.

As explained above, most of the current chemical pulping processes utilize sulfur in some form. In bringing about the solution of wood components, the sulfur combines with constituents of the wood to produce gaseous and particulate compounds, which may degrade the quality of the air. This process causes the mills to emit sulfurous gases, mists and water vapor.

Kraft mills burn the spent cooking solutions (black liquor) after the pulp has been extracted to recover chemicals for reuse and to generate further heat for the production process. These mills commonly emit still

greater amounts of chemicals into the environment as mists and gases, as well as salts and dust particles.

1. Sulfur Dioxide

One sulfur gas formed in chemical pulping is sulfur dioxide, a highly irritating toxic compound. The consequences of sulfur dioxide pollution are summed up in the following statement:

> Sulfur dioxide is the most worrisome of the major pollutants... While not toxic to man in the concentrations ordinarily found in the atmosphere, it can cause acute crop damage in relatively small concentrations. In industrial regions it causes nickel to corrode twenty-five times as fast as in rural air, and copper five times as fast. And under certain conditions it kills people. One of its derivatives, sulfuric acid mist, can get past the body's natural filtration system and penetrate deep into the lungs, causing severe damage...[9]

Recent evidence also indicates that plant life can be damaged by sulfur dioxide pulp mill emissions. In a pre-trial report on the Hoerner Waldorf mill in Missoula, Montana, it was shown that tissues of plants evidenced diseases caused by those gases as far as 15 miles away from the mill site. In a more extreme case, the mountainsides rising next to a no-longer operating Westavco mill in Luke, Maryland, were virtually stripped of all foliage decades ago; they have never fully recovered.

In Jacksonville, Florida which has six paper and pulp mills within a 50-mile radius, the acid in the air is so damaging that a warranty certificate for a car paint job in the area reads:

> If your car is constantly exposed to extreme deterioration such as those caused by acid from a paper mill, or sitting directly on a beach, then our warranty must not be considered to be in effect since even a new car will rust under such conditions.[10]

Despite this, the Environmental Protection Agency stated in 1971 that although there are sulfur dioxide emissions from kraft pulp mills, "these almost never exceed the current standard because of recovery processes essential to the economics of pulp production.[11]

2. Hydrogen Sulfide and Methyl Mercaptans

The most annoying pollutants in terms of human comfort are hydrogen sulfide and methyl mercaptans, produced by chemical reactions in the kraft process. These gases are characterized by a pervading and penetrating stench which can be spread for thirty miles in a strong wind. (Mercaptans are the active agents which give a skunk its typical odor and hydrogen sulfide smells like rotten eggs.) According to a study on noxious odors conducted by the Copely Corporation this kraft mill odor is the third most serious, affects the second largest area per source, and is the longest lasting of all modern odors.[12]

In addition to its noxious qualities, hydrogen sulfide is highly toxic in large quantities. In 1966 and 1968, several workers at the International Paper Company's Mobile, Alabama mill coming in close contact with high concentrations of the gas, suffered unconsciousness, loss of memory, and hallucinations.[13]

3. Particulates

Fine particles of dust, chemicals, and carbons are a serious nuisance. In high concentrations they can aggravate respiratory and lung diseases such as emphysema and asthma. They have also been known to cause such a visibility problem that cars must drive with their headlights on in broad daylight because "the heavy blanket of foul smelling smoke from a kraft plant effectively blots out the sun."[14]

The Hoerner Waldorf mill located in the Missoula Valley in Montana emits approximately 11 thousand pounds of black soot and fly ash each day from the boiler stacks alone.[15] The particulates and corrosive gases formed and emitted from the chemical pulping and recovery processes are so damaging to car paint that many kraft mills, including International Paper in Panama City, Florida and Weyerhaeuser in Everett, Washington provide a car rinsing service for their employees to drive through each day after work.[16]

Obviously the effects of these pollutants are multiplied when the atmosphere inhibits rapid dispersal. A temperature inversion zone can often trap polluted air in a local area. In an inversion, warm air sits on the cooler surface air below, preventing it from rising. It acts as a lid, holding down the air and any pollutants it contains. Contrary to popular belief, inversions are quite common in many areas. In some valley areas, such as Lewiston, Idaho the condition occurs as much as 80 per cent of the time, while in non-valley systems, the air may be inverted 40-50 per cent of the time.[17] As one author stated: "The air above us is not a boundless ocean. Much of the time it is a shallow stagnant pond, and we are the fish at the bottom."[18]

C. WATER POLLUTION

In 1969 the pulp and paper industry "borrowed" over two trillion gallons of water in processing sixty million cords of pulpwood.[19] As a material for the manufacture of pulp and paper, water is second in importance only to the wood fiber itself. Pulp and paper's consumption of water ranks among the highest of all U. S. industry, averaging 6.5 million gallons daily.[20]

Logs are debarked by high pressure hydraulic jets. Machinery is water cooled by a constant flow of thousands of gallons. Water is also used in cooking and washing pulp and as a method of transporting fibers throughout the entire processing procedure. Between each of the phases of the pulping process, fibers are dilluted with up to 99 per cent and then reconstituted. Depending on the process, pulp mills use a maximum of between 34,000 and 62,000 gallons of water per ton of pulp.[21]

Few of the mills today discharge completely untreated water, but only a handful meet state and federal standards. In 1969, it was estimated that the industry discharged 15 per cent of the total industrial effluent of the United States.[22] A recent study by the Council on Economic Priorities that centered on the 131 mills that accounted for 68 per cent (87 thousand tons) of the total daily 1969 pulp and paper production, states that these mills use at least 2.4 billion gallons of water daily and discharge nearly two-thirds of it without meeting proper standards for primary or secondary treatment. According to the study, virtually no water treatment is given to 833.5 million gallons of effluent (35.4 per cent of the total) that is discharged every day.[23]

1. Solid Effluent

The daily effluent discharged from a mill may contain tons of solid fibers, bark, uncooked wood chips and dirt. These solids sink to the bottom of slow moving streams and lakes forming beds of sludge which can ruin the quality of water and destroy the bottom habitat for aquatic life. Paper mills located on Lake Champlain in upstate New York have in the past (now primarily International Paper Company mill at Ticonderoga, N.Y.) dumped enough solid waste to cover 300 acres of lake bottom in depths up to 12 feet.[24]

2. Organic Residuals

Mill effluents contain organic residuals dissolved from wood during the pulping and bleaching process. These residuals become pollutants when they begin to make excess demands on water oxygen supply. The pulp and paper industry is by far the largest contributor to this form of environmental degradation (the food processing industry and inadequate sewage treatment are the other primary contributors). The oxygen-robbing potential of waste effluent is called its biochemical oxygen demand (BOD).

Bacteria in water can naturally decompose a portion of these organic materials, as long as there is enough oxygen in the water. If the concentration of waste gets too high, the bacteria overfeed, overpopulate, and consume the available oxygen supply, with disastrous consequences for the surrounding aquatic ecosystem. In such cases, decay of organic matter still takes place, but it is done anaerobically (bacteria that do not use free oxygen but organically or inorganically bound oxygen, common sources of which are nitrates and sulfates). Gases such as methane and hydrogen sulfide result from this

process. Ecosystems that have been polluted by excess organic material have foul odors and look black and bubbly. Extreme examples are rare, but the condition is not unknown. For example, almost all the streams in the Japanese papermaking city of Fuji lack oxygen.[25]

The BOD varies with the type of pulping process used. In the effluent from small mechanical mills, for example, where no chemicals are used and only fiber and water-soluble organic wastes are discharged, it ranges from 30 to 60 pounds per ton of pulp produced. The BOD from sulfite mill effluent, on the other hand, ranges from 750 to 1,000 pounds per ton of pulp due to the strong chemicals used for pulping.[26]

An estimated 0.17 pounds of oxygen are required by bacteria to decompose a daily human discharge of waste, while nearly 1,000 pounds of oxygen are required by bacteria to decompose untreated wastes from one ton of bleached sulfite pulp. A typical calcium sulfite mill which produces 200 tons of pulp daily can create a BOD load equivalent to that of the raw wastes from one million people.[27]

3. Foam and Discoloring Matter

Two other pollutants from pulping, foam and discoloring matter, are more annoying than dangerous. The foam results from small amounts of resin, fatty acids and chemicals in the discharge. It bubbles up from the mill sewer outfalls spreading brownish "suds" all over the water. Where highly resinous woods are used for pulping (as in the Southeast), foam on rivers can be built up to several feet in thickness.

The dark color in mill effluent can be both distressing and harmful.

When it spreads over a surface of a stream or lake, it can and does block out sunlight necessary to the ecological balance of a body of water.

4. Mercury

A dangerous pollutant from pulp and paper manufacture is mercury. It is used as a fungicide to preserve pulp or ships in warm weather, as a slimicide, and as a catalyst in chemical bleach production. The paper industry consumed 46 thousand pounds of mercury in 1968, according to a Bureau of Mines estimate.[28]

A poisonous metallic element with a high residual character, mercury can find its way into the food of man through the food chain of his environment. In 1970 Canadians and Americans learned that thousands of tons of fish had assimilated mercury that reached rivers and lakes from a variety of industrial sources. Everyone assumed that heavy mercury would sink to the bottom and remain inert. But scientists discovered that bacterial action converts inorganic mercury into a much more toxic organic form, methyl mercury. From bottom mud this may be carried through the aquatic food chain into the fish we eat. When mercury in large amounts lodges in the kidneys, brain, and other vital organs, it causes irritability, flushed skin, and loss of hair, teeth and nails. It can lead to brain damage, blindness, insanity and death.

D. CURRENT POLLUTION ABATEMENT

According to George H. Weyerhaeuser, president of the Weyerhaeuser Corporation, one of the 5 largest wood products industries, "Anyone who thinks the pollution problem isn't being given a lot of attention is crazier than hell."[29] The American Paper Institute states emphatically that the paper and pulp industry is giving pollution a lot of attention and money. The Institute reports that $1 billion has been spent by the industry since 1950 in protecting 50 million acres of forest land; $516 million has been spent on water pollution abatement; and $130 million on air pollution reduction. They also claim that almost 90 per cent of the 800-plus pulp, paper, and paperboard mills give some treatment to their effluent and air emissions. The Institute has also declared that $60 million was spent in 1970 just to maintain and keep pollution control devices operating.[30]

Some of these expenditures were for research, and it has paid off, both for the industry and for communities affected by their polluting activities. Through technological improvements, lumber and plywood mills no longer burn the bulk of their wastes. Most goes into hardboard pulp, and other products. Operators currently use 80 per cent of the log, compared to 50 per cent 20 years ago.[31] Uses from mulch to auxiliary fuel have been found even for tree bark. Some mills have installed equipment to absorb chlorine from bleach sollutions, recover chemicals, reduce odors and burn black liquor residues. Electrostatic precipitators, similar to those used in power plants, trap particulates and prevent them from being emitted.

A case in point is Georgia-Pacific's plant in Crossett, Arkansas,

which draws 53 million gallons of water daily, mostly from its own man-made lake and cleans up the effluent before it flows at a controlled rate into the Ouachita River. Chemists for the company report that the new controls reduced water pollution by 95 per cent.[32]

Many alternatives are being found to dumping wastes into waterways. Industrial research has developed a variety of sulfite liquor by-products such as binders, emulsifiers, and gels. The St. Regis Paper Company in Rhinelander, Wisconsin, for example, grows torula yeast on sugar residues and converts lignins into adhesives and additives for concrete.

Weyerhaeuser and Owens-Illinois are the two forest products industries that are in the forefront of anti-pollution technology, and were so long before ecology interest rose to its present pitch, according to the Council on Economic Priorities. All 4 Owens-Illinois mills have adequate air and water pollution controls.

Of Weyerhaeuser's 22 pulp mills, 9 were built since World War II with state-of-the-art controls (not perfect, but technologically and economically feasible). Some need upgrading, but the company has consistently recognized pollution problems and has tried to solve them.

Undoubtedly, governmental standards and enforcement pressures have helped. In 1970 President Nixon stated that the rivers and harbors section of the 1899 Refuse Act which prohibits industrial discharge into navigable waters without the permission of the U. S. Army Corps of Engineers, would be strictly enforced. The law requires that industry

disclose what is being dumped into the rivers, at what rate, and the concentration of the chemicals or effluents.

State-of-the-art pollution control is what every mill should seek and is capable of achieving. It is the highest level of control technologically and economically feasible at any given time. Because of this, it is a flexible concept which changes as new, more efficient controls are introduced.

1. Air Pollution Control

A variety of methods have been found to be useful in controlling particulate emissions from pulp mills. Even with state-of-the-art controls, efficiencies of 99-plus per cent are possible.[33] Odor from the kraft process remains a persistent problem defying even optimal controls.

Every mill in the country has to cope with the soot and ash particles emitted from oil, bark, and coal-fired boilers. Mills which burn used pulping liquor for chemical recovery have the added problem of controlling chemically coated fly ash from the recovery furnaces; and, of course, there's the sulfurous and mercaptan gas emissions to contend with.

a. Mechanical Dust Collectors

The oldest and most common devices used in the pulp and paper industry are mechanical or cyclone dust collectors. These set up a continuous, high-velocity air current to spin particles against the inside walls of pipes leading to the mill stacks. The larger bits of soot and ash, after striking the walls, fall down into a hopper at the bottom of the stack and are periodically removed. Mechanical collectors, costing about $250 thousand per installation, provide adequate control of emissions from low sulfur oil and

bark boilers, but are inadequate for coping with fine soot and ash particles emitted from coal boilers.

Almost all mills rely completely on these devices to control power boiler emissions even though one company pollution control director admitted "Mechanical collectors just get the 'golf balls'. We used to consider them sufficient; but with the new, stricter pollution control standards, we would probably have to think of them as antiques."[34]

b. Scrubbers

Scrubbers are able to remove about 95 per cent of the particulate matter, and over 90 per cent of the sulfurous gases from the exhaust passing through the mill stacks.[35] A stream of water, sometimes containing chlorine and other chemicals, is sprayed through the exhaust,"scrubbing" soot and ashes and absorbing large volumes of gaseous compounds much as the rain "scrubs" dirt from the air. Scrubbers, costing as much as the mechanical collectors, should be used on all coal boilers. They may also be used alone or in conjunction with precipitators on production and recovery stacks.

c. Electrostatic Precipitators

Electrostatic precipitators have been used in the industry for over half a centruy and are the most efficient particulate control device. They cost between $500 thousand and $1 million. The most modern ones are able to remove up to 99.5 per cent of the particulate emissions from the recovery operation stacks. A precipitator consists of a box-like structure containing positively and negatively charged rods and plates which create an electro-

static field. It is placed at the entrance of a mill stack and as the gas stream passes by the rods, each soot particle is given a charge and in turn is attracted to the plate with the opposite charge. From time to time the plates have to be "rapped" and the clinging particles fall to the bottom of the precipitator.

d. Black Liquor Oxidation

Mechanical dust collectors, precipitators, and scrubbers can jointly control all the major air pollutants except the odorous gases formed during kraft pulping production and chemical recovery. The odors may be controlled in two ways. The most widely accepted method is black liquor oxidation which prevents the gases from forming by combining oxygen with the dissolved sulfur-containing compounds in the spent black liquor. A resulting chemical reaction forms a non-odorous gas instead of the foul smelling hydrogen sulfide and methyl mercaptan compounds. For greatest efficiency, the oxygen should be infused into the liquor both before and after it is evaporated ("weak" and "heavy" black liquor oxidation). The capital expenditure for an effective system would be approximately $500 thousand per installation.

e. Evaporation Systems

Non-direct contact evaporation systems attack the problem of odorous gas formation during the final evaporation phase of the recovery cycle. In this phase, hot combustion gases are usually forced through the liquor to evaporate it. Physical and chemical reactions between the combustion and the black liquor release the odorous gases. Non-direct contact evaporation systems eliminate any contact between the liquor and the combustion gases, thus preventing formation of the odorous compounds. Such systems have long been

used in other countries. Sweden, for example, installed them in all kraft mills by 1968.[36] American companies have only started using the system in the last two years. With the most efficiently operated black liquor oxidation or non-direct contact evaporation systems, mill odors may be reduced to a concentration of only one part per million. Since the smell is still detectable and distressing at concentrations of one part per billion, no final solution to this form of pollution is currently available.

2. Water Pollution Control

Pulp mill water effluent may be treated in three separate stages: primary, secondary, and tertiary. The Council on Economic Priorities found that of the 2.4 billion gallons of water used daily by 131 mills throughout the country in 1969, only 28.9 per cent (680 million gallons) was treated for removal of heavy solid wastes. Full secondary treatment was provided for approximately 33.6 per cent (792 million gallons) and a mere 2.1 per cent (50 million gallons) received tertiary treatment. The only plant that provided tertiary treatment was the Georgia-Pacific mill in Crossett, Arkansas.[37]

a. Primary Treatment

Primary sedimentation is a strictly physical process that removes 75-95 per cent of the heavy solids. The mill effluent remains in a settling pond or a large cement clarifying tank until the solid wastes fall to the bottom. Water from which most of the solids have settled overflows the top. Additional solids may be removed by screens and "savealls" which filter and reclaim lost fibers from the effluent. Adequate primary treatment may

entail a capital cost of between $300 thousand and $1 million depending on the size of the mill.

b. Secondary Treatment

Secondary treatment of water is a biological process which removes 80-95 per cent of the dissolved oxygen-demanding organic and inorganic materials in the effluent. It stimulates and speeds up the natural oxidation process by which bacteria in the water consume wastes. Equipment for secondary treatment is more varied and expensive than that for primary treatment. Capital cost ranges from $2 million to $4 million.

Secondary treatment consists of large holding ponds or natural stabilization lagoons which retain effluent for months until natural processes decompose the dissolved wastes. This biological oxidation is accelerated in aerated lagoons where mechanical aerators force oxygen into the effluent to fortify the waste-consuming bacteria. Such lagoons can treat up to 20 times as much effluent as those of similar size without aeration, achieving 80-90 per cent BOD reduction in only ten to twenty days.

Activated sludge further hastens decomposition, but it is the most compact, elaborate, and expensive form of secondary treatment. A biological "sludge", rich in bacteria and oxygen, is whipped into the waste water by giant eggbeater-like aerators. The bacteria quickly attack and break down the waste so that effluent can be discharged within hours.

c. Tertiary Treatment

Tertiary treatment is a catchall phrase for any treatment beyond secondary. The process depends on the nature of the wastes, and only a

handful of pulp mills have installed any form of this advanced pollution control technique.

d. Spray Irrigation and Out-Fall Pipes

Two other methods of disposing of the effluent are often included in listings of treatment: spray irrigation and out-fall pipes with diffusers. Both techniques are often condoned by state control agencies. They involve piping the effluent from the mill and dispersing it over a wide area by spraying it on the land or disposing of it miles out in the ocean or in a river. To accept this means of inadequate treatment, one must assume that nature has an infinite capacity to assimilate man's wastes, which, of course, is a false assumption.

E. COST ANALYSIS

Investment in the paper industry has tended in the past to follow a five year cycle. The cycle begins with heavy investment to meet actual and anticipated growth in demand. Competition within the industry tends to generate production to overcapacity with the result that prices decline, profits are depressed and investment is in turn cut back. As demand catches up to supply the cycle is repeated. This market pattern tends to keep overall profits below the average for manufacturing firms in general.

Kraft pulp production is a direct function of the demand for paper and paper products, while competitive prices for substitutes are the prime determiner of kraft pulp's price position. A large share of kraft production makes available materials for the manufacture of containers and packaging goods, including wrapping paper, bags, corrugated boxes, frozen food

containers, milk cartons, and other food containers. Competition comes from producers of aluminum, plastics, and aluminum substitutes. The kraft industry does appear to have a grasp on a relatively constant share of the market due to continued research and development directed toward meeting consumer needs. There are a large number of buyers in the market as evidenced by the wide range of potential uses of kraft pulp. Prices tend to react freely to relative changes in supply and demand, but demand has tended to increase steadily in rough proportion to population growth.

In recent years the open market sale of kraft pulp has decreased substantially. The reason is that paper companies have tended to integrate and include kraft paper firms in conglomerates consuming most of the available pulp in the direct production of paper and paper products. About 8 per cent of the available kraft pulp is marketed by independent firms without paper making facilities and by integrated firms that produce surplus pulp for the open market.[38] This makes it difficult to estimate the market reaction to pollution control within the kraft industry. In addition, analysis of the impact of control costs are hindered by the presence within the entire paper industry of firms that manufacture non-paper products, including lumber, metal containers, and other diverse products. But estimates have been made based on the fact that kraft pulp is a significant supplier to the total industry.

Cost of control varies depending upon the location and size of the plant and its equipment. The Environmental Protection Agency determined in 1971 that about 45 per cent of the pulp mills in this country produce close to 1,000 tons daily, while 16 per cent produce approximately 140 tons each day. Total

annual cost of equipment to control particulate matter emissions for the high capacity plants was estimated at about $380 thousand ($1.14/ton), while the low capacity plants could install control equipment at an estimated cost of $61 thousand ($1.24/ton). When control costs ranging between $1.14 and $1.24 per ton are compared to the market price of pulp ($124/ton in 1968) it is apparent that the cost of particulate control equipment is relatively low.[39]

Precise estimates of the cost of controlling other pollutants in the pulping process are not available at this time, but the following generalizations can be made. Pollution control equipment for a brand new mill represents about 10 per cent of the capital cost. For older mills, however, the cost may be as much as two or three times higher. Yet it seems apparent to many that these costs only partially reflect the debt that such mills owe the environment. How much the consumer or the people employed by the pulp and paper industry will demand or be asked to pay still remains to be seen. James Quigley, vice president for environmental quality at the U. S. Plywood - Champion Papers Company made the following comment on a report titled, The Economic Impact of Pollution Control, issued jointly by the Environmental Protection Agency, the Council on Environmental Quality, and the Department of Commerce:

> I certainly take no exception to the report's general conclusion that the current air and water quality standards can be met in the United States without imposing an insuperable burden on American industry. The report makes clear that this effort will have a

> depressive effect on our gross national product and will result in the closing of as many as 300 plants with the resulting loss of up to 125,000 jobs. If this is the price we have to pay for a reasonably clean environment, while it is expensive, it is not prohibitive.[40]

Once capital investment is made, more money must be spent to maintain and operate anti-pollution equipment. It is this fact that will hopefully stimulate industries such as the pulp and paper industry to discover and implement technology that will enable the profitable recycling of waste products. Currently, processes to recover such chemicals as ethyl alcohol, acetic acid, vanillin and others from the spent pulping liquor in the kraft chemical pulping process, or to use the sugars found in the wood to grow yeast, are in limited use.

Already, anti-pollution expenditures are bumping other priority projects. Scott Paper chairman Harrison F. Dunning recently remarked:

> The industry has got to automate just to offset the generous wage concessions going on today. It will continue to do that. But expansion could definitely be slowed up a bit because of anti-pollution outlays.[41]

In 1970, a total of $750 million dollars was spent by the 131 pulp mills studied by the Council on Economic Priorities, in an effort to reduce air and water pollution to state-of-the-art levels. But this figure must be considered in the context of the $20 billion gross sales and $2.2 billion expenditures by the entire industry during that year. It appears that only 4 per cent of the total annual sales is being channeled into efforts to combat the paramount environmental problems that pulp produced for the manufacture of paper products represents.

E. ATTITUDES OF THE INDUSTRY

1. Pulp and Paper Producers

In the study of the pulp and paper industry referred to above the Council on Economic Priorities found a wide range of attitudes among the various company managements. Some were cooperative while others refused information. Only two of the twenty-four companies surveyed by the Council on Economic Priorities have records of sustained interest and effort toward achieving excellent pollution control at their mills: Owens - Illinois and Weyerhaeuser. All four Owens-Illinois mills have adequate air and water pollution controls. The extensive lagoon system for effluent treatment at the company's Valdosta, Georgia mill was designed and built long before such facilities were required.

Weyerhaeuser is one of the five largest paper and pulp companies. It operates 11 pulp mills, 9 of which have been built since World War II with state-of-the-art controls. In addition, the company has innovated many techniques for control, such as the first kraft mill odor control system.

The attitudes of these two companies contrast sharply with the records of companies such as St. Regis, Potlatch and Diamond International. St. Regis operates nine pulp mills, seven of which have neither primary nor secondary water treatment. As a result, 174.3 million gallons of essentially untreated effluent are discharged daily into public waterways. Three of the company's kraft mills have made no effort toward odor control.

Potlatch has serious air pollution problems at both of its mills, and

only recently installed primary water treatment at one.

Diamond International's four mills are all inadequate in both their air and water pollution control facilities. Only one Diamond mill has even primary water treatment. The company opened a new tissue mill in Maine in 1971 with no water treatment at all, and will operate without any controls for the next four years until Maine's pollution control requirements to into effect.

In general, the records of all other companies studied by the Council indicate perhaps one or two mills at which a real effort has been made to clean up and the rest in fair to poor condition. Most have taken a "we will wait until we are told what to do by the State," approach.[42]

2. Forest Products Lobbies

Allowable cutting in national forests has more than doubled in the last 20 years. Behind this trend are the powerful and active forest products lobbies.

Three national associations represent the expanding resource needs of loggers, saw mill operators and forest products manufacturers. The American Paper Institute (API), which prior to 1965 was known as the American Paper and Pulp Association, has its central office in New York City; the American Pulpwood Association (APA) is also located in New York; and the largest, the National Forest Products Association (NFPA) which was formerly known as the National Lumber Manufacturers Association. The NFPA has its offices in Washington, D. C. and is the oldest of the national

timber groups. It employs an exceptionally large staff of 70 persons.

Subsidiary divisions of each national group and individual corporations as well, participate in legislative and administrative decisions through testimony at congressional hearings and informal meetings with congressmen, the Department of Agriculture and Department of the Interior officials.

Often this participation is encouraged and guided by the leadership of any or all of the three national organizations. Many times they are combined with other economic interest groups such as mining, oil, and electric power because of the compatibility of their economic objectives with the Department of Agriculture and Department of the Interior policies of multiple use of resources. The compatible objectives encourage loose intergroup coalition across industry lines. Very often these coalitions are formed temporarily to defend the status quo of access to public domain resources, and to "counterclaim" persistent and increasing demands of conservationists.

Functioning as advocates for specific organizational goals, the national interest groups participate in land resource policy-making activities. These include, new proposals to modify existing resource allocations, coalition and alliance building among organizations with compatible needs, and bargaining with competing groups and office-holders in the executive branch and in Congress.

III. CONCLUSION

The Environmental Protection Agency's waste management office tells us that industry dumps 4.7 million tons of waste a year into coastal waters (the most productive part of the ocean); 2.7 million tons are waste acids or wastes from refineries and paper mills. Hundreds of miscellaneous industries account for the rest.

What is the point of this statistic, or even of the facts presented in the preceeding sections? It reveals something which is more serious than the harm it might produce. It should remind us of our ignorance; that we are hardly aware of the potential hazards from hundreds of substances that we have emitted and discharged unthinkingly into our environment.

Ecologist Barry Commoner summarized it nicely. "Like the sorcerer's apprentice, we are acting upon dangerously incomplete knowledge. We are, in effect, conducting a huge experiment on ourselves." Unwittingly, we have created a new and dangerous world with our affluent demands.

The cirsis to our environment brought on by industry is grave evidence of the disastrous deception hidden in the productivity and wealth of our modern, technology-based society. This wealth has been gained by relatively rapid, short-sighted exploitation of the environment - creating a debt so large and so diffused that in the next generation it may, if unpaid, wipe out most of the wealth it has gained us.

This does not necessarily mean that to survive the crisis we will need to sacrifice the many benefits that technology has given us, but closing factories that cannot or will not control their emissions or effluents may be a

partial answer. The C. B. Eddy pulp mill complex, directly across the Ottawa River from Canada's Parliament Building, was bought by the government for $29.5 million for the sole reason of shutting down the polluting operations. One-half the property (44 acres) was closed, resulting in a 90 per cent reduction of air and water pollution. Affluence seems to have generated ecological apathy and socially wasteful types of production rather than promote the total welfare of individuals. We need sober research that will initiate industrial changes that can be carried out without seriously reducing the present level of useful goods available for consumption, and at the same time maintain a beautiful environment.

How can this be achieved? Industry has the key. The same technology that has promoted industrial growth can be re-directed to meet the challenge of profitable recycling and maximum use of resources. Increased profit margins of production must surely follow innovations in efficiency. Increased efficiency will mean less waste. Less waste in the form of air emissions or water effluents from industry will allow nature to cleanse and purify itself and bring us back to a healthy "man-with-nature" balance.

FOOTNOTES

IRON AND STEEL INDUSTRY

1. In April 1972, the mayor of El Paso, Texas requested Federal aid to help relocate 150 west El Paso families who live near the four smokestacks of American Smelting and Refining Company. Thirty-five children were hospitalized because of high levels of lead in their blood, allegedly caused by the smelting company. The situation was reported in the National Observer on April 1, 1972. Last year, the entire town of Knapsack, Germany was relocated because of extreme pollution caused by the phosphate industry in the town.

2. "A Big Steel Union Makes War on Pollution," Business Week, December 1971, p. 35.

3. "Industry Starts the Big Cleanup," Fortune, February 1970, p. 53.

4. Bethlehem Steel Corporation, Keep It Clean, (Booklet 2604 A, Bethlehem Steel Corporation) p. 17.

5. "Industry Starts the Big Cleanup," Fortune, February 1970, p. 53.

6. "Pollution and Industry: Pros, Cons of Growing Fight," U. S. News and World Report, November 22, 1972, p. 27.

7. The Economics of Clean Air: Report of the Administrator of the Environmental Protection Agency to the Congress of the United States (Washington: U.S. Government Printing Office, 1971), p. 4-70.

8. Bethlehem Steel Corporation, Keep It Clean, op. cit., p. 10.

9. Ibid., p. 18.

10. The Economics of Clean Air, op. cit., p. 4-69.

11. Ibid., p. 4-72.

12. Ibid., p. 4-71.

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1. Encyclopaedia Britannica, (Chicago: Encyclopaedia Britannica Corp., 1964) Vol. XVII, p. 232.

2. The National Geographic Society, As We Live and Breathe (Washington: National Geographic Society, 1971), p. 113.

3. Southern Pulpwood Conservation Association, How Paper Comes From Trees (Atlanta: Southern Pulpwood Conservation Association, 1964), p. 14.

4. National Geographic Society, As We Live and Breathe, op. cit., p. 106.

5. Ibid., p. 104

6. Ibid.

7. E. R. Hendrickson, W. G. Tucker, J. E. Robertson, Advances in Air Quality Improvement in the Wood Pulping Industry, (Cincinnati, Ohio: National Air Pollution Control Administration, 1970), p. 4.

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10. Council on Economic Priorities, Paper Profits: Pollution in the Pulp and Paper Industry, (Washington: Council on Economic Priorities, 1971) Vol. 1, No. 6, p. 9.

11. The Economics of Clean Air: Report of the Administrator of the Environmental Protection Agency to the Congress of the United States (Washington: U.S. Government Printing Office, 1970), p. 4-73.

12. Council on Economic Priorities, Paper Profits: Pollution in the Pulp and Paper Industry, op. cit., p. 14.

13. Harris K. Williams, "HS_2 - Not Enough Is Known About It," Pulp and Paper, May 1970, p. 140.

14. Creighton Peet, "The Effluent of the Affluent," American Forests Magazine, May 1969, p. 19.

15. "Hoerner - Waldorf's Clean Air Proposals," The Sunday Missourian, November 9, 1969, p. 4.

16. Council on Economic Priorities, Paper Profits: Pollution in the Pulp and Paper Industry, op. cit., p. 7.

17. U. S., Department of Health, Education, and Welfare, Lewiston, Idaho - Clarkston, Washington Air Pollution Abatement, prepared by Public Health Service (Washington: U.S. Government Printing Office, 1967), p. 34.

18. Fortune, op cit., p. 4.

19. American Paper Institute, The Paper Industry's Part in Protecting the Environment, (Washington: American Paper Institute, 1970) p. 29.

20. National Geographic Society, As We Live and Breathe, op. cit., p. 111.

21. J. Alfred Hall, The Pulp and Paper Industry and the Northwest, U. S. Department of Agriculture (Washington: U.S. Government Printing Office, 1969), p. 34.

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23. Council on Economic Priorities, Paper Profits: Pollution in the Pulp and Paper Industry, op. cit., p. 12.

24. Wall Street Journal, June 25, 1970, p. 1.

25. Sterling Brubaker, To Live on Earth: Man and His Environment in Perspective (Baltimore: Johns Hopkins Press, 1972) p. 108.

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29. "A Costly Cure," Forbes, January 1, 1971, p. 166.

30. National Geographic Society, As We Live and Breathe, op. cit., p. 108.

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32. Ibid.

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35. Ibid.

36. Ibid.

37. Ibid.

38. Economics of Clean Air, op. cit., p. 476.

39. Ibid., p. 477.

40. National Observer, March 25, 1972.

41. Forbes, op. cit., p. 167.

42. Ibid.

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